November 17, 1997 F/AKC2:CR

CRUISE RESULTS
Chartered Vessel Cruise No. 97-1
F/V *Golden Dawn*
1997 Bycatch Research Cruise
July 11-28, 1997

A 19 day cruise to make observations of groundfish behavior in the vicinity of trawls aboard the chartered vessel *Golden Dawn* commenced in Dutch Harbor, Alaska on July 11, 1996. This cruise continued a project to facilitate the development of more selective bottom trawls to reduce bycatch problems. The selectivity of fishing gear results from the interactions between fish and the stimuli presented by the fishing gear. Underwater video systems were made to observe fish reactions to unmodified trawl gear as well as several trawl modifications. Tests were conducted on two grate systems to release undersized fish, a low opening trawl to avoid roundfish bycatch in sole fisheries, an opening in the top of the intermediate to release halibut and roundfish, and a towed camera system to evaluate seafloor habitats. An infrared video system was used to observe variations in fish behavior at low light levels.

AREA OF OPERATIONS AND ITINERARY

All research trawling was conducted in the eastern Bering Sea, with one additional site south of Unimak Island. Trawl locations were selected for likelihood of encountering important target and bycatch species of Bering Sea commercial fisheries and with sufficient light and water clarity near bottom to make video observations possible. Species sought for observations included Pacific cod (*Gadus macrocephalus*), walleye pollock (*Theragra chalcogramma*), Pacific halibut (*Hippoglossus stenolepis*) and a range of species of smaller flatfish (Pleuronecetes).

July 11-13	Loaded vessel, Dutch Harbor, AK
July 14-27	Field operations in the Bering Sea

July 28 Unloaded vessel, Dutch Harbor, AK

OBJECTIVES

1. The characteristics of flexible grates to achieve escape of undersized fish were tested, including:

   a. ability of the grate system to maintain configuration after multiple deployments from a net storage reel,

   b. size selection of pollock when grate is installed in the top of the trawl intermediate, and

   c. size selection of rock sole, yellowfin sole and halibut when the grate is installed in the lower intermediate.

2. A narrow trawl with a low vertical opening was tested for its ability to capture sole while avoiding roundfish and halibut bycatch.

3. Tests were made on two versions of an Open Top Intermediate (OTI)system for separating roundfish and large halibut from sole.

4. Pollock behavior in the trawl intermediate section was observed at low light levels under infrared illumination to study the effects of light level.

5. Each of the trawl components that contact the seafloor were observed during towing to provide documentation for a subsequent study of trawl impacts on seafloor communities.

6. A video system was tested for its ability to evaluate seafloor substrate and animal communities.

METHODS

Video equipment - A variety of video cameras, lights and deployment methods were used to make experimental observations. Silicon intensified target (SIT) cameras, which can produce video at very low light levels, were used wherever ambient light was sufficient. This avoided any behavioral effects associated with the presence of artificial lights. When conditions required artificial lights, charge coupled detector (CCD) cameras were

used with incandescent lights or the SIT camera was used with a much dimmer green, LED (light emitting diode) illuminator. Finally, an experimental camera-light system was used to avoid the effects of artificial light while observing fish behavior where ambient light conditions were too low for the SIT cameras to produce an image. An intensified CCD camera (ICCD) with high sensitivity in the infrared range was used with an infrared LED illuminator. While the rapid absorption of infrared light by water limited the range of this combination, the insensitivity of fish vision to infrared light made observation possible without providing illumination for the subject fish.

Two systems were used to power and aim the camera-light packages while recording the video produced. One SIT camera was mounted in a mechanism which allowed real time manipulation of the camera orientation. Power, as well as control and video signals, were transmitted over a specialized 16 conductor cable. The aiming unit included a scanning sonar, green LED illuminator and altimeter, as well as tilt, light, depth and temperature sensors to supplement the video observations. This system was suspended in the trawl mouth to make observations near the trawl footrope or attached to the mesh in other parts of the trawl.

Self-contained systems were also used for fish behavior observations. Batteries and a video recorder in an underwater housing were connected to fixed camera and light combinations to provide power and record the video output. These systems were started when the trawl was launched and operated throughout the trawl tow without real time viewing or manipulation.

The principal study trawl was a commercial two panel bottom trawl constructed of polyethylene netting with headrope and footrope lengths of 47.5 m and 56.4 m. It was fished behind 6.5 m^2 steel Super V trawl doors using 82.5 m single sweeps and 27.5 m double bridles. Trawl spread and height were measured with an acoustic trawl mensuration system. Towing speeds were varied between 3 and 4 knots and the ship’s positions, based on GPS (Global Positioning System) fixes, were recorded throughout each tow. A tilt sensor and logger, mounted in a pipe which dangled from the footrope, was used to monitor bottom contact of the trawl. Temperature and depth were recorded with two data logging sensors, one on the headrope and one on the trawl intermediate. The sensor on the intermediate also recorded the ambient light level.

Grates for Size Selection

Two grates were constructed from fiberglass rods and were tested for their ability to maintain a consistent configuration after multiple deployments from a net storage reel and for achieving size selection of pollock and flatfish. The grates consisted of 24 fiberglass rods 244 cm (8 ft) long and 11 mm (0.5 in) in diameter, held together by neoprene strips with holes at constant intervals to regulate the width of the gaps between the bars. The strips divided the length of the bars into 6 sections, each about 41 cm (16 in) long. Fiberglass and neoprene were used in the design and construction to allow the grate to sufficiently bend to wrap onto a net storage reel and then return to a consistent configuration when the net was again set.

The pollock grate was installed in the top half of the trawl intermediate, with the gap between bars set at 44 mm (1.75 in). A mesh cover was installed over the grate to capture escaping fish and route them to a secondary codend for enumeration. Floats and support lines were installed on the cover so that it did not mask the opening. Installation in the top half took advantage of a previously observed tendency of pollock to contact this area while passing through the intermediate.

The flatfish grate was installed inside the lower half of the intermediate so that it formed a V in cross section. This V was closer to the bottom of the intermediate at the forward end of the grate than at its aft end. Bars were set at 32 mm (1.25 in) spacing. At the aft end of the grate, the intermediate was divided to lead those fish which had passed through the grate to a separate codend from those which had not. This sloped V configuration was selected to take advantage of the tendency of flatfish to remain near the bottom of the intermediate and to move laterally more than vertically.

Grate testing tows lasted 15 minutes. After each tow was completed, the catch from each codend was sorted, weighed and enumerated. The lengths of individuals from species of interest were measured to determine size compositions. If more than 300 individuals were present, a subsample was selected for length analysis. Individuals representing a range of sizes of pollock, rock sole and halibut were selected for width (pollock) or thickness (sole and halibut) measurements. Width and thickness were measured with calipers at the thickest (or widest) point that could not be easily compressed, at the back edge of the

preoperculum. These measurements were taken to allow a comparison of the grate spacing to the appropriate dimensions of the fish that passed through it.

Minimal trawl

Observations of sole behavior ahead of the footropes of commercial-scale trawls have indicated that a large proportion are herded to the center of the footrope and pass into the trawl in that section, remaining relatively low as they pass back. It was hypothesized that a relatively small scale trawl should not catch much less than a full scale trawl if it were fished with herding sweeps of the same dimensions. Such a trawl should have a greatly reduced bycatch of roundfish, halibut and crabs due to their different herding and entry behaviors.

To test this hypothesis, a small two seam trawl (11.7 m headrope, 15.1 m footrope)was rigged to fish ahead of the full scale trawl in such a way that all fish herded by the sweeps would be led to the small trawl. Fish avoiding the small trawl would encounter the full scale trawl. The footrope of the minimal trawl was constructed of 20 cm (8 in) diameter rubber disks over a steel chain. An auxiliary set of sweeps, 27.5 m (15 fm)long, connected the small trawl to a point on the main sweeps 55 m (30 fm) ahead of the main trawl. The two trawls were fished together (15 minute tows) and their respective catches were sampled for comparison.

Open Top Intermediate Observations

The Open Top Intermediate (OTI) is a trawl modification which previous observations and tests have indicated can allow escape of roundfish and large halibut through an opening in the top of the intermediate while retaining small sole. An exempted fishery to test this modification under commercial conditions was planned for early August, 1997. To facilitate these tests, two industry constructed OTI systems, which were to be used in that fishery, were observed during this cruise allow them to be tuned to an optimum configuration. OTI configuration and fish behavior were observed with multiple video cameras.

Low light behavior observations

The availability of ambient light is considered likely to influence the behavior of fish encountering trawl gear. Since

even the most sensitive video cameras do not function below the threshold of fish vision, it has been difficult to observe behavior at very low light levels. The infrared assisted video system described above was installed to observe fish behavior in the intermediate and near the footrope of the study trawl during tows in areas with very low light levels.

Seafloor Contact

Because the study trawl was to be used in a subsequent project on trawl impacts on seafloor communities and because there was a need to document such interactions. Several tows were conducted with cameras in position to document trawl/seafloor contact.

Observed locations included the doors, sweeps, wings and center of the footrope.

Seafloor survey

To advance the development of video tools for assessing demersal communities and seafloor types, the cable controlled video package was modified to allow independent towing over the seafloor. Extra floats were attached to its top and two meter lengths of chain were dangled from its lower rails to regulate the height that it maintained above the seabed. The SIT camera was used with and without auxiliary illumination.

RESULTS

Sixty six experimental tows were completed providing approximately 90 hours of video and sonar observations. Towing locations included Dublin Bay and Unimak Bight as well as a range of locations on the eastern Bering Sea shelf between Amak Island and St. George Island. Operating dimensions of the study trawl averaged 3.5 m in height and 31.3 m in width.

Grates

Both of the fiberglass grates went on and off of the net reel easily, with no additional hanging up in the mesh or other handling problems. The shape of the openings remained consistent throughout the tests. Video observations confirmed that the grates were not masked by the cover mesh and that fish moved through them unimpeded. Gilling of fish in the grates was rare.

Pollock Selection

Fifteen tows were conducted with the pollock selection grate. The first three tows were in the Amak Island area at about 90 m depth, where nearly all of the pollock were longer than 45 cm. The tow site was changed to the area of Priblof Canyon, south of St. George Island, looking for more small fish to test the selection characteristics of the grate. On the way there, two tows were made on pollock schools in 174 m depth, but only large pollock (> 55 cm) were encountered. The pollock in the Priblof Canyon area were mostly between 35 and 45 cm in length, which was suitable for testing the grate, though more fish shorter than 35 cm would have been preferred. These tows were made in 115 m depth and produced catch rates averaging 434 kg/hr, far below commercial rates.

Figure 1 shows the size selection data for all tows combined. Pollock width measurements indicated that the bar spacing (44 mm) corresponded to the width of pollock which averaged about 440 mm long. Above this length, very few pollock passed through the grate, demonstrating that this measurement of pollock width is a good indicator of the size of a slot that they can pass through. Below 44 cm, there is a clear selection function with smaller individuals being caught at lesser rates. The capture rate does not reach 50% until around 360 mm. Although few fish smaller than 350 mm were observed, capture rates appear to continue to decrease at these smaller sizes. As tested, the usefulness of this selection grate would be quite limited by the wide range of sizes over which selection varies. A sharper selection curve might be achieved by increasing the length of the grate, providing more escape opportunities.

Flatfish selection

After several test tows, six comparison tows were conducted with the flatfish separation grate, all in the Unimak Bight area at depths averaging 50 m. Principal flatfish at this site were rock sole and halibut. The selection data for rock sole (Figure 2) shows a relatively weak trend with more than 90% of those above 360 mm length being caught in the main cod end (not passing through the grate) as compared to about 70% of rock sole below 300 mm. Very few halibut went through the grate, even of those thinner than the gap width of the grate. Thickness measurements indicated that rock sole or halibut less than 450 mm in length should have been physically capable of passing through

the grate. While more than 100 halibut were observed between 330 and 390 mm length, only 8% of these escaped. All halibut 400 mm and longer were retained.

Minimal Trawl Experiment

Eight comparison tows were completed with the minimal trawl, four in the Unimak Bight(50 m depth) and four near Amak Island (70 m depth). The species compositions varied between areas. Rock sole and halibut were the main species in the Unimak Bight, while the catch near Amak was dominated by yellowfin sole, with some rock and flathead sole. The minimal trawl fished as intended with a vertical opening of about 30 cm (1 ft) and a width of about 10 m, less than 3% of the opening of the main study trawl. The percentage of fish vulnerable to the main trawl which were taken by the minimal trawl was estimated by dividing the minimal trawl catch by the sum of both catches.

Comparison of catches indicated that approximately 50% of most flatfish species were captured by the minimal trawl (Table 1). The exceptions to this were halibut, a species which North Pacific groundfish trawlers try to avoid, and yellowfin sole, a principal target species and the only species caught in near commercial quantities in these tests. Less than 20% of the halibut (by weight) were caught in the minimal trawl. Halibut length data showed that this trawl caught a higher proportion of small halibut. Forty four percent of the halibut under 45 cm in length were taken by the minimal trawl compared to only 8% of halibut over 60 cm in length. Only 21% of the yellowfin sole were taken by the minimal trawl, with no noticeable size effect.

Other species that sole fisheries sometimes need to avoid are roundfish and crabs. Cod catches by the minimal trawl varied between 21 and 35%, while only 10% of the few pollock observed were taken by the minimal trawl. This trawl also accounted for only 10% of the Tanner crabs taken.

While a low headrope height and narrow capture area reduced roundfish, halibut and crab capture rates more than those of most flatfish, the extremely small dimensions used in this test resulted in greater flatfish losses than would be acceptable in most commercial fishing situations. Of particular concern is the low capture rate of yellowfin sole. Analysis of video on this gear will be conducted with an emphasis on detecting changes that

would retain the bycatch reductions, while improving retention of the sole species.

Low light behavior

Video of fish behavior in low light conditions was taken during 12 tows with the infrared illuminated camera system. The ICCD/infrared system did provide useful images at short ranges, though mud clouds frequently disrupted the picture. During five of these tows, the camera viewed the intermediate of the trawl, six were used for observations of the pollock selection grate and one looked at the center of the footrope. Pollock behavior from these videos will be compared with video of behavior at higher light levels.

Open Top Intermediate tests

Nine tows were spent checking the fishing configurations of two Open Top Intermediates which were subsequently used in commercial scale tests of this concept in an exempted yellowfin sole fishery. Improvements to the rigging were found for both devices.

Seafloor Contact

Twelve tows were made to observe interactions between the trawl and the seabed at a range of locations in the trawl system. Video of doors, sweeps, wings and the center of the footrope were obtained.

Seafloor survey

The cable mounted camera system was towed independently over the seafloor at four locations. The system performed quite well, maintaining a consistent view even when fished over rough substrate. Seafloor types observed included smooth, sandy substrates, very rough, rocky substrates and muddier substrates. The ability to manipulate the camera permitted a comparison of forward, lateral and straight down views.

SCIENTIFIC PERSONNEL

Name	Organization	Position

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Table 1.- Catch rates of main and minimal (low) trawls and percent taken by the minimal trawl by weight and numbers at two towing sites.

	Unimak Bight						Amak Island					
	Weight (kg)			Number			Weight (kg)			Number		
Species	main	low	%	main	low	%	main	low	%	main	low	%
Halibut	860	216	**20**	405	182	**31**	18	3	**15**	6	2	**25**
Rock Sole	393	423	**52**	936	1010	**52**	123	132	**52**	596	465	**44**
Yellowfin Sole							1382	366	**21**	4206	1106	**21**
Flathead Sole							88	90	**51**	231	232	**50**
Butter Sole	24	26	**52**	61	71	**54**						
Starry Flounder	89	41	**31**	37	19	**34**						
Arrowtooth Flounder							116	138	**54**			
Alaska Plaice							42	39	**48**	33	31	**48**
Skates	300	118	**28**	4	5	**56**	16	9	**36**	3	1	**25**
Pacific Cod	400	216	**35**	174	89	**34**	174	60	**25**	63	17	**21**
Walleye Pollock							30	3	**9**	27	3	**10**
Tanner Crab							97	11	**10**	390	40	**9**

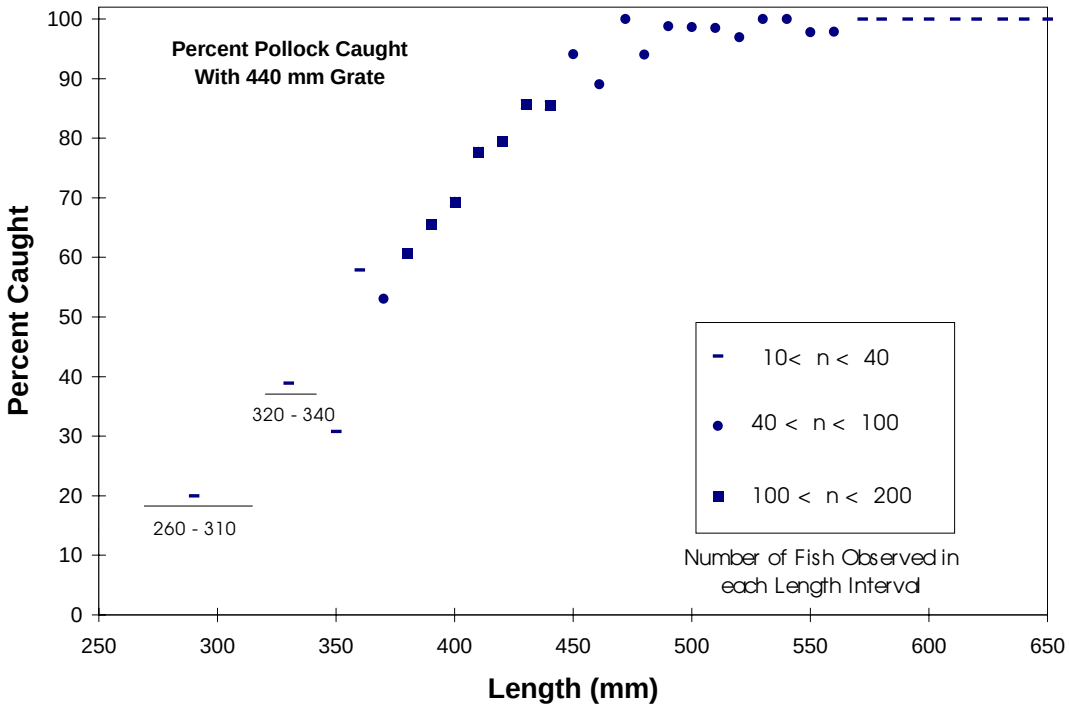

Figure 1. Size selection of walleye pollock encountering a 440 mm grate in the top panel of a trawl intermediate.

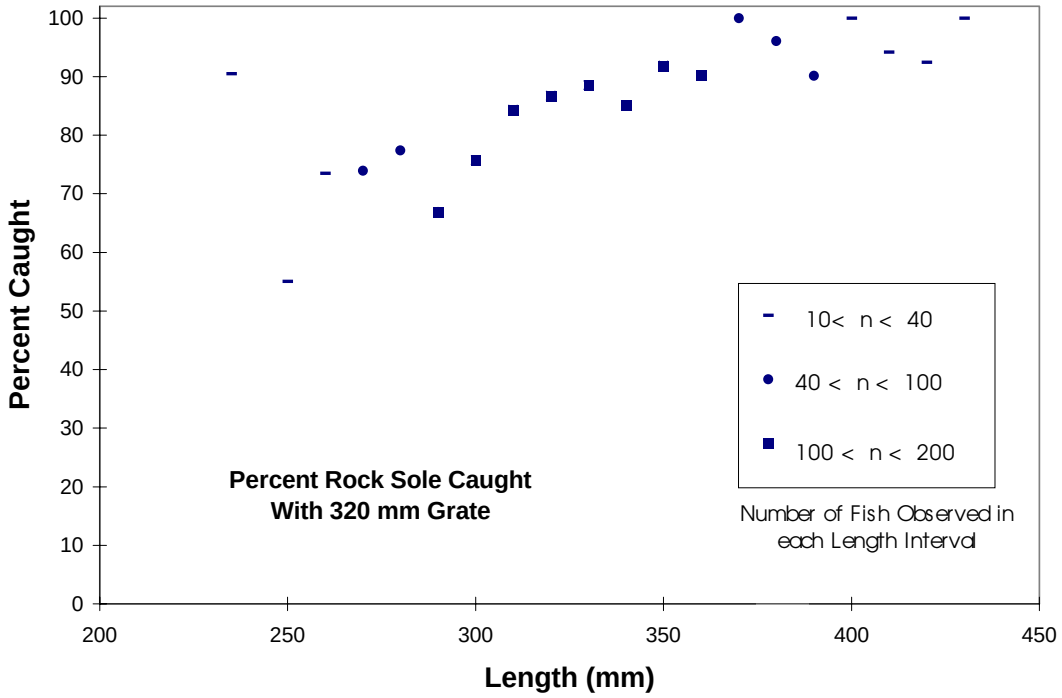

Figure 2. Size selection of rock sole encountering a 320 mm grate in the lower half of a trawl intermediate.